Forest Health Protection

TECHNOLOGY
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Integrated Pest Management

Appalachian Integrated Pest Management Gypsy Moth Project: Summary and Bibliography

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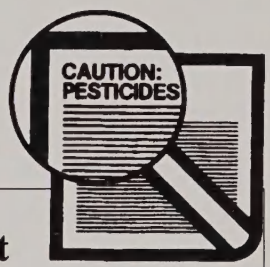

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For additional copies of this publication or publications listed in the Bibliography, contact Lisa Cress in Morgantown, WV at (304)285-1563.

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Introduction

This paper summarizes the major project components of the Congressionally mandated Appalachian Integrated Pest Management Gypsy Moth (AIPM) Project. This paper also provides a bibliography of publications produced in connection with the 5-year project. A subject index to the publications, which are listed alphabetically by author, is provided.

Background

The gypsy moth (*Lymantria dispar* [L.]) is a serious defoliator in the broad-leaved eastern forests. It was introduced from Europe into North America near Boston, Massachusetts, in 1869. Before 1960, efforts were made to stop its spread by importing natural enemies, aerially applying insecticides, and establishing barrier zones. Efforts to eradicate this introduced defoliator from the Northeast were abandoned during the 1960's and efforts focused on suppressing high-density populations in broad-leaved eastern forests.

The USDA Forest Service began a pilot study of the feasibility of using an integrated pest management (IPM) approach to manage low-level gypsy moth populations in Maryland in 1983. Federal, State, and County agencies participated in the Maryland Integrated Pest Management Gypsy Moth (MD-IPM) Project over a wide range of ecological, geographical, and land-use areas on approximately 20,200 hectares (50,000 acres) in Anne Arundel, Prince Georges, and Howard Counties (Reardon *et al.* 1993). The Project ended in 1987 and was successful in reducing low-level gypsy moth populations, but additional technologies and biopesticides for use in environmentally sensitive areas were needed, as well as demonstration of the IPM concept over a mountainous area.

In 1987, Congress directed the Forest Service to continue efforts to manage the leading edge of gypsy moth populations along the Allegheny Mountains in Virginia and West Virginia (Reardon 1991). As a result of this direction, the Forest Service established the 5-year AIPM Project and initiated the development of an Environmental Impact Statement. This 5-year project began in late July 1987.

Project Objectives

The AIPM Project had four objectives:

1. to minimize the spread and adverse effects of the gypsy moth within the Project area;

2. to develop a prototype IPM structure consisting of standardized sampling protocols, decision matrices for intervention activities at low-level gypsy moth populations, computer-based geographic information systems, and an educational program;

3. to continue the development of intervention activities for the management of isolated low-density infestations; and

4. to assess the feasibility of implementing a coordinated Federal and State program over a large area.

Project Area

The project encompassed 20 counties in the State of West Virginia and 18 counties in the State of Virginia for a total of 5 million hectares (12.4 million acres) (*Figure 1*). The AIPM-Project area was divided into four zones (*Figure 2*) based on pheromone trap catch and egg mass data (modified along county boundaries), to more precisely define the degree of success in accomplishing each objective within the project area. Description protocols (*Table 1*) and decision protocols for use of intervention activities (*Table 2*) were developed for each zone.

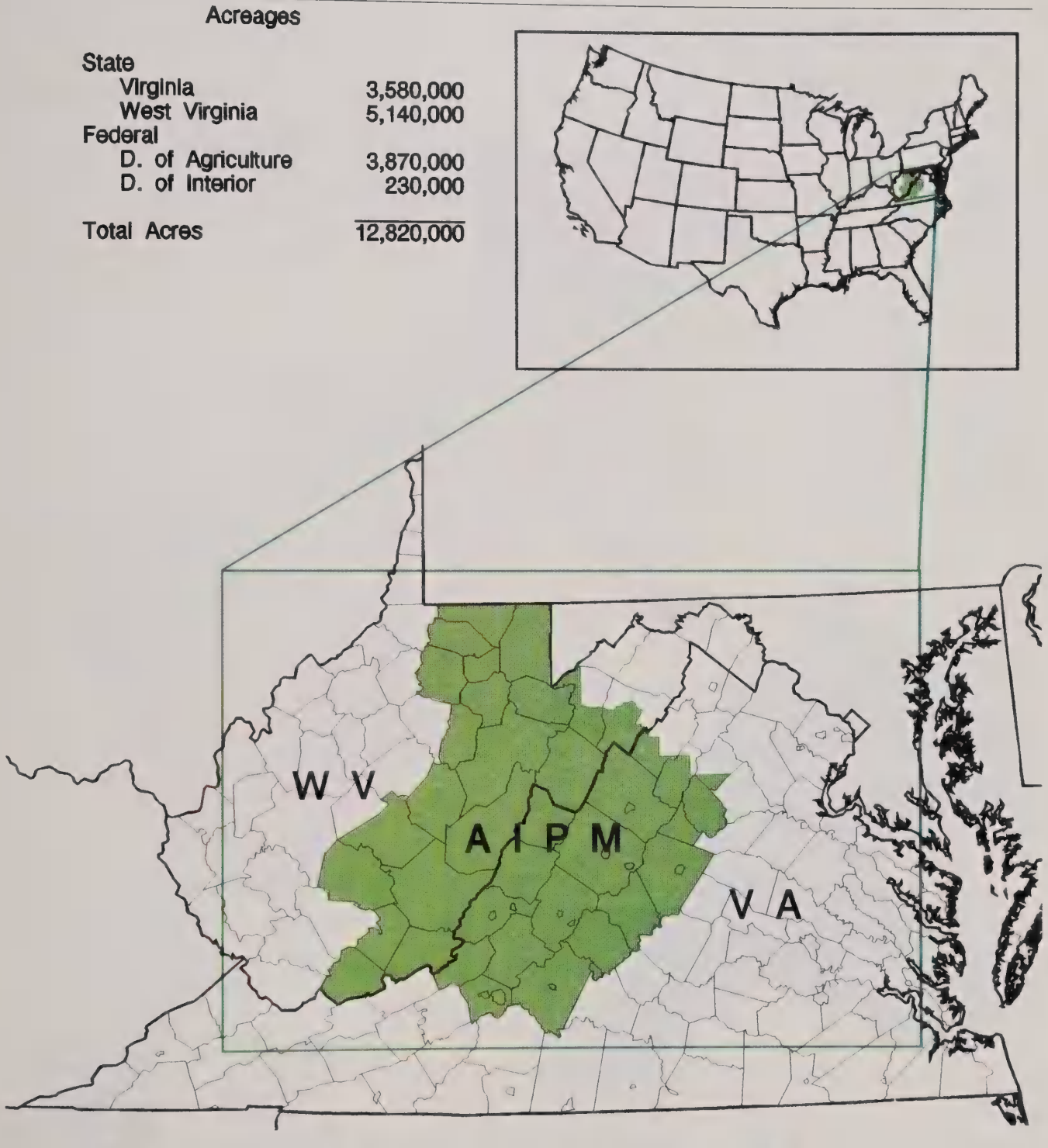

Figure 1. *AIPM Project Area Location*

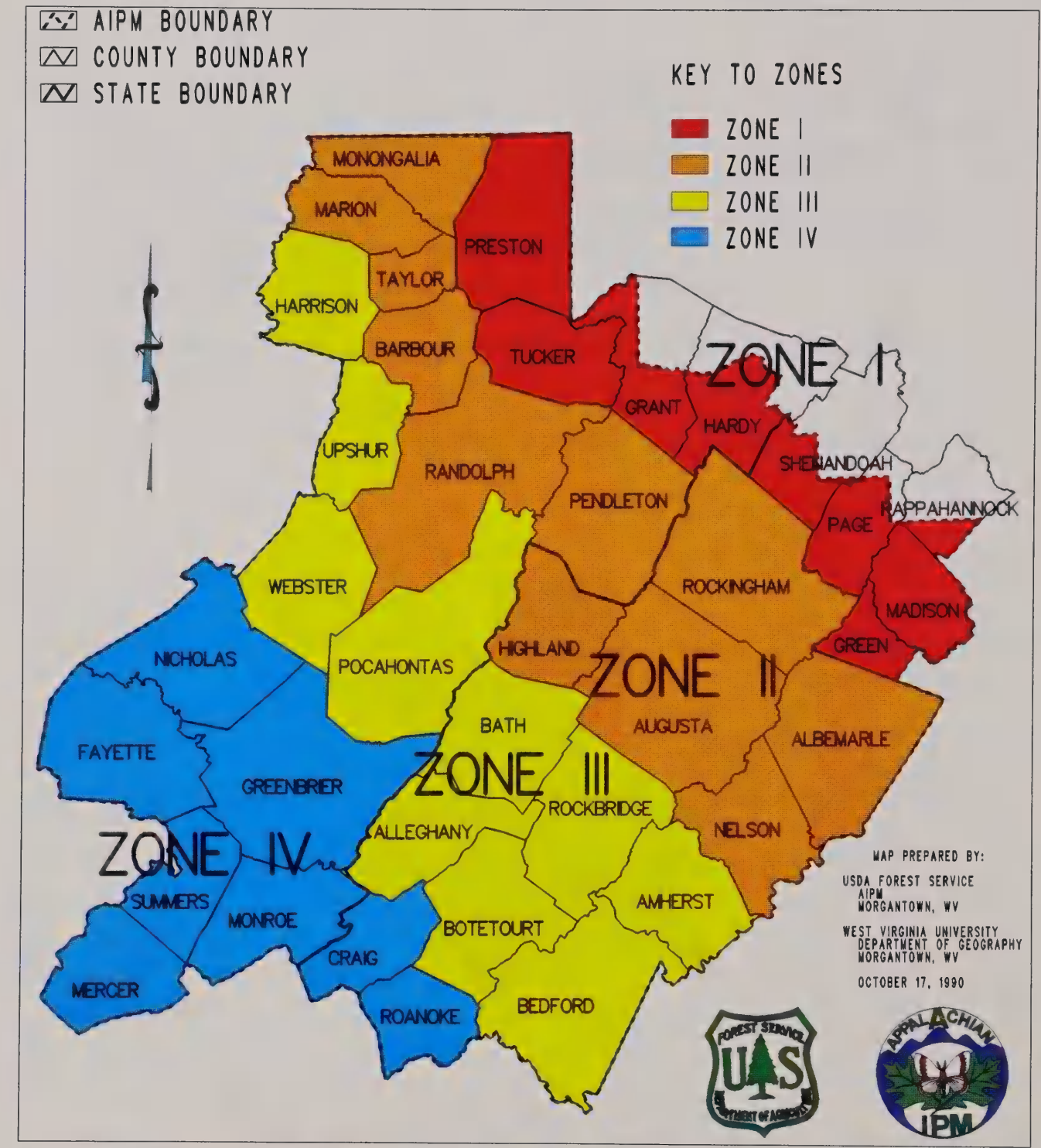

Figure 2. *AIPM Gypsy Moth Project Area 1991 Intervention Zones*

Table 1. *Description protocols for gypsy moth zones within the AIPM Project.*

Zone	Management Objective	Biological Parameters	Monitoring/Survey	Intervention Tactics
I	- prevent damage which exceeds management objectives	male moths average greater than 500 per trap on area basis (also considerother factors, *e.g.*stand susceptibility, egg mass counts)	monitor male moth populations on a 6-km grid or 2- to 3-km; egg mass surveys **only** in priority areas	*Bt* (1 or 2 appl.), DFB, Gypchek, No Action
II	- maintain populations below 250 egg masses/ acre in priority areas and minimize spread into Zone III	male moths average 200-500 per trap on area basis	monitor male moth populations at a 6-km, or 2- to 3-km grid; egg mass surveys **only** in priority areas	*Bt* (1 or 2 appl.), DFB, Gypchek, No Action
III	- detect and maintain populations below 50 egg masses/acre; reduce natural and artificial spread; maintain below 50 egg masses/acre	male moths average 10 to below 200 per trap on area basis	monitor male moth populations at 2- or 3-km grid; at 100, 250, or 500 m grid at delimiting sites; egg mass surveys	*Bt* (2 appl.), DFB, Gypchek[b], No Action[a] and low-level tactics (pheromone flakes, Bt and mass trap, sterile pupae, mass trapping[c])
IV	- intensive detection and management of populations; reduce natural and artificial spread	male moths average below 10 per trap	monitor male moth populations at 500 m or 1-km grid; at 100, 250, or 500 m grid at delimiting sites when funds are available	*Bt* (2 appl.), DFB, Gypchek[b], No Action[a], and low-level tactics (pheromone flakes, *Bt* and mass trap, sterile pupae, mass trapping[c])

[a] *No action is only an option in very limited situations within Zones III and IV.*

[b] *Gypchek is not recommended for operational use against low-level populations. It can be used on an experimental basis in areas which require a gypsy moth specific tactic and population levels are too high for the use of low-level gypsy moth specific tactics.*

[c] *Low-level tactics (pheromone flakes, Bt and mass trap, sterile pupae, mass trapping) are recommended for use in limited situations (i.e. isolated populations).*

Table 2. *Decision protocols for use of intervention activities within the AIPM Project.*

In:	If the management objective is:	The average egg mass per acre count is:	The available intervention activities[2,3]
Zone I - Generally Infested Portion of Project Area	**to minimize damage such as defoliation impacts or tree mortality in:** timber or mast production areas or uninhabited woodlots...	greater than 1,000	no action, Bt (1- or 2- appl.), Dimilin
	environmentally sensitive areas...		*no action, Gypchek*
	forested residential communities...	greater than 500	no action, Bt (1- or 2- appl.), Dimilin
	environmentally sensitive areas...		*no action, Gypchek*
	high use areas, for example, recreation areas, parks, or along scenic highways or streets	greater than 250	no action, Bt (1- or 2- appl.), Dimilin[5]
	environmentally sensitive areas...		*no action, Gypchek*
	special areas such as trout streams or historic sites...	greater than 250	no action, Bt (1- or 2- appl.), Dimilin
	environmentally sensitive areas...		*no action, Gypchek*

Table 2. *Decision protocols for use of intervention activities with the AIPM Project (cont.).*

In:	If the management objective is:	The average egg mass per acre count is:	The available intervention activities
Zones II and III - Transition Portion of Project Area	**to minimize population buildup...**	greater than 250	no action[4], *Bt* (2-appl.) Dimilin
	environmentally sensitive areas...		*no action[4], Gypchek[6]*
	to minimize natural or artificial spread from high use or urban/ suburban areas and protect special values...	greater than or equal to 50	no action[4], *Bt* (2-appl.) Dimilin[5], Gypchek[6]
		less than 10	low level tactics - pheromone flakes, sterile pupae or mass trapping[7]
Zone IV - Isolated Portion of Project Area	**to minimize natural and artificial spread from all areas and to apply intensive detection...**	5 or more male moths	no action[4], Bt (2-appl.), Dimilin[5], low level tactics - pheromone flakes, sterile pupae or mass trapping[7]
	environmentally sensitive areas...		*no action, Gypchek[6]*

[1] *Stand susceptibility and vulnerability should be considered along with population density, defoliation history, management objectives, and resource values. High susceptibility is defined as 50% or more of the basal area in oak, or 80% or more of basal area in favorable species.*

[2] *Specific activity is to be recommended by land managers, reviewed by Planning committee; and approved by Steering committee.*

[3] *The release/augmentation of exotic/established species of parasites and invertebrates predators of the gypsy moth or the ground application of Luretape are not recommended for use within the Project Area.*

[4] *No action is only an option in very limited situations within Zones III and IV.*

[5] *The operational use of Dimilin at these densities and high-use areas will require prior majority approval by a subgroup of Planning Committee members: Hacker, McAninch, Reardon, Swain, and Wolfe.*

[6] *The use of gypchek at densities less than 100 egg masses/acre is recommended for use in limited situations as only preliminary data is available concerning its efficacy at these densities.*

[7] *The low-level tactics (pheromone flakes, Bt and mass trapping, sterile pupae, mass trapping) are recommended for use in limited situations such as isolated populations. These tactics are not fully operational but ready for pilot testing.*

Project Components

This section summarizes the technology and methods used in the AIPM project in terms of several components: Survey and Monitoring, GIS and Data Management, Intervention Methods, Technology and Methods Development, Evaluation of Data, and Technology Transfer.

Survey and Monitoring

The AIPM Project was structured around an intensive survey and monitoring system. A 1-km (0.6 mile) fixed point sampling grid was established on Universal Transverse Mercator coordinates. At each accessible 3-km fixed grid point in West Virginia or 2-km grid point in Virginia, a standard USDA milk carton pheromone trap was placed on the bole of one overstory tree. The traps were placed at the grid points in May and June, checked mid-season, and in September were removed and male moths counted. Field personnel placed the traps at approximately the same location each year. More intensive grids and surveys were implemented in localized areas within the 3-km^2 (West Virginia) or 2-km^2 (Virginia) cells to delimit populations.

The forest stand at each grid point was characterized as to susceptibility to defoliation (Valentine and Houston 1984) and hazard rated (Herrick and Gansner 1986). In fall and winter, surveys were conducted using a sequential sampling technique at selected grid points, and in adjacent cells to estimate egg mass densities and delineate boundaries of potential problem areas (Fleischer *et al.* 1991). Egg masses were collected from the infested areas to provide viability data. To determine defoliation, sketch maps and high altitude optical-bar photographs of the project area were reviewed.

GIS and Data Management

The design standardization and implementation of extensive and intensive sampling programs was the most critical project component. A geographic information system (GIS) was an integral part of the AIPM Project and was used to provide needed graphic and textual information to project decision makers. The GIS computer software used at several interacting locations was ARC/INFO, the personal computer version pcARC/INFO, or both. Each location had a different configuration of computer hardware and peripheral equipment, but data could be readily transferred back and forth through the use of 9-track computer tapes and floppy diskettes.

The gypsy moth data that the AIPM cooperators collected were entered into the GIS. Data themes included male moth trap, egg mass survey, proposed treatments, and defoliation data. Additional types of information were collected and input into the GIS, including State, county, city, forest, and park boundaries, roads, hydrography, and airport locations. U. S. Geological Survey 1:24,000 scale topographic maps or "quads" were used as the base for many of the layers of information in the AIPM GIS.

To improve access to the map layers, AIPM Project personnel developed a map display and analysis system for use at a local level (*e.g.*, County). This system provided a menu-driven display environment on an IBM PC compatible microcomputer through which maps of gypsy moth populations could be viewed in combination with maps of stream networks, forest cover, etc. Rockbridge County, Virginia, was the demonstration site for the development of the display and analysis system (Fleischer *et al.* 1992).

Life stage and other supportive data were collected at approximately 9,500 fixed-grid points and within approximately 9,500 3-km^2 (West Virginia) or 2-km^2 (Virginia) cells. The data were recorded on standardized optical scan forms. The data was processed, presented, compared, and analyzed using the methods developed for the MD-IPM project.

Computer-based systems for data acquisition, management, and utilization were developed, and decision-making based on this information.

Intervention Methods

The AIPM project focused on developing management strategies for a range of population densities through pheromone monitoring, egg mass surveys, and defoliation surveys. The intervention methods used operationally during the Project included aerial application of the growth regulator diflubenzuron (Dimilin 25W and 4L), the bacterial insecticide, *Bacillus thuringiensis kurstaki* (*Btk*), the gypsy moth nucleopolyhedrosis virus product Gypchek, and the slow release formulation of disparlure (Disrupt II).

In Zone I and, to a lesser degree, Zone II of the AIPM Project area, potentially defoliating populations of the gypsy moth were prevalent, and the aerial application of diflubenzuron and *Btk* were the major intervention methods implemented. The aerial application of *Btk* and Disrupt II were used in Zones III and IV against low density populations to slow the spread and buildup of these populations. A chronology of treatment acreages within the AIPM Project Area for fiscal years 1989 through 1992 is summarized in Table 3.

Technology and Methods Development

Methods development studies and special projects were an important component of the AIPM Project. Four intervention methods were evaluated and refined: Gypchek, *Btk*, mating disruption, and mass trapping with the milk carton trap at 23 traps/ha (9 traps/acre). Three new intervention methods were investigated: the fungi *Beauvaria bassiana* and *Entomophaga maimaiga*, and inherited sterility. Also, the AIPM Project funded several non-target studies: impact of *Btk* on food of the Virginia Big-eared Bat, impact of *Btk* on canopy and understory lepidopteran larvae within an oak forest, impact of diflubenzuron on selected non-target organisms in broadleaved watersheds, impact of the fungus *Entomophaga maimaiga* on non-target lepidopteran larvae; and impact of gypsy moth defoliation on aquatic macroinvertebrates, trout populations, stream chemistry, and black bear populations in Shenandoah National Park.

Table 3. *Chronology of Treatment Acreage within the AIPM Project Area, FY 1989 through FY 1992.*

Treatment Method	FY 1989	FY 1990	FY 1991	FY 1992
			acres	
Btk	12,536	129,184	67,555	95,084
Dimilin	29,378	128,644	64,408	59,013
Gypchek	1,080	1,329	2,081	2,052
Disparlure	2,500	524	5,565	10,900
Total	**45,494**	**259,681**	**139,609**	**167,049**

The AIPM Project sponsored numerous projects to improve aerial application technology for use during suppression projects. One of the major accomplishments was the development of a Swath Kit, which is a portable system to accurately calibrate and characterize spray systems. Another major accomplishment was the development of techniques to analyze insecticide deposit on foliage.

Evaluation of Data

A structure for carrying out the regionally based IPM project was established and management decisions were based, in part, on pheromone trap, and egg mass and defoliation survey data. These data were recorded for each year and displayed on local as well as on project-wide maps *(Figures 3A-3I)*. Trends in these data were critical for suppression of potentially defoliating and low level expanding gypsy moth populations.

Technology Transfer

The AIPM Project developed several types of documents to transfer information on emerging technology in a timely manner. One or two-page bulletins were issued periodically to provide nontechnical descriptions of developing technology for the public. Technical booklets were prepared to provide detailed descriptions of developing technology for land and resource managers and scientific coworkers. Also, articles were published in refereed and trade journals and meeting proceedings, and presentations were given at public and professional meetings.

The AIPM Project supported an information specialist with overall responsibility for coordinating the flow of information to cooperators both within and outside the Project area, as well as for developing and disseminating documents (*e.g.*, brochures, exhibits) to the public, resource managers, industry and government officials. Within the Project area, each county in Virginia had a county coordinator and in West Virginia four regional coordinators were responsible for the dissemination of information within their local area. The Project published a monthly newsletter, Demonstration Project News, with a distribution of over 1,200.

Conclusions

The AIPM Project successfully accomplished all four of its objectives with the development of a prototype IPM structure and intervention activities and technology for managing low-density infestations. The project also provided critical input into the subsequent regional Slow-the-Spread Pilot Project (1993-1999). A prototype IPM structure was developed and utilized by Rockbridge County, Virginia, as a result of the AIPM Project. An IPM approach for the regional management of gypsy moth populations was not adopted by the cooperating States and Federal agencies within the AIPM Project areas, however, mainly due to the high costs associated with maintaining the intensive survey and monitoring system. Nevertheless, the AIPM Project has had these far-reaching results: (1) numerous publications documenting the technology and methods developed; (2) ongoing implementation of these technologies and methods during operational suppression and eradication projects (conducted during Federal and State cooperative programs) and continued evaluation of low-level intervention tactics in the Slow-the-Spread Pilot Project, and (3) transition to technology development with national scope (National Center of Forest Health Management).

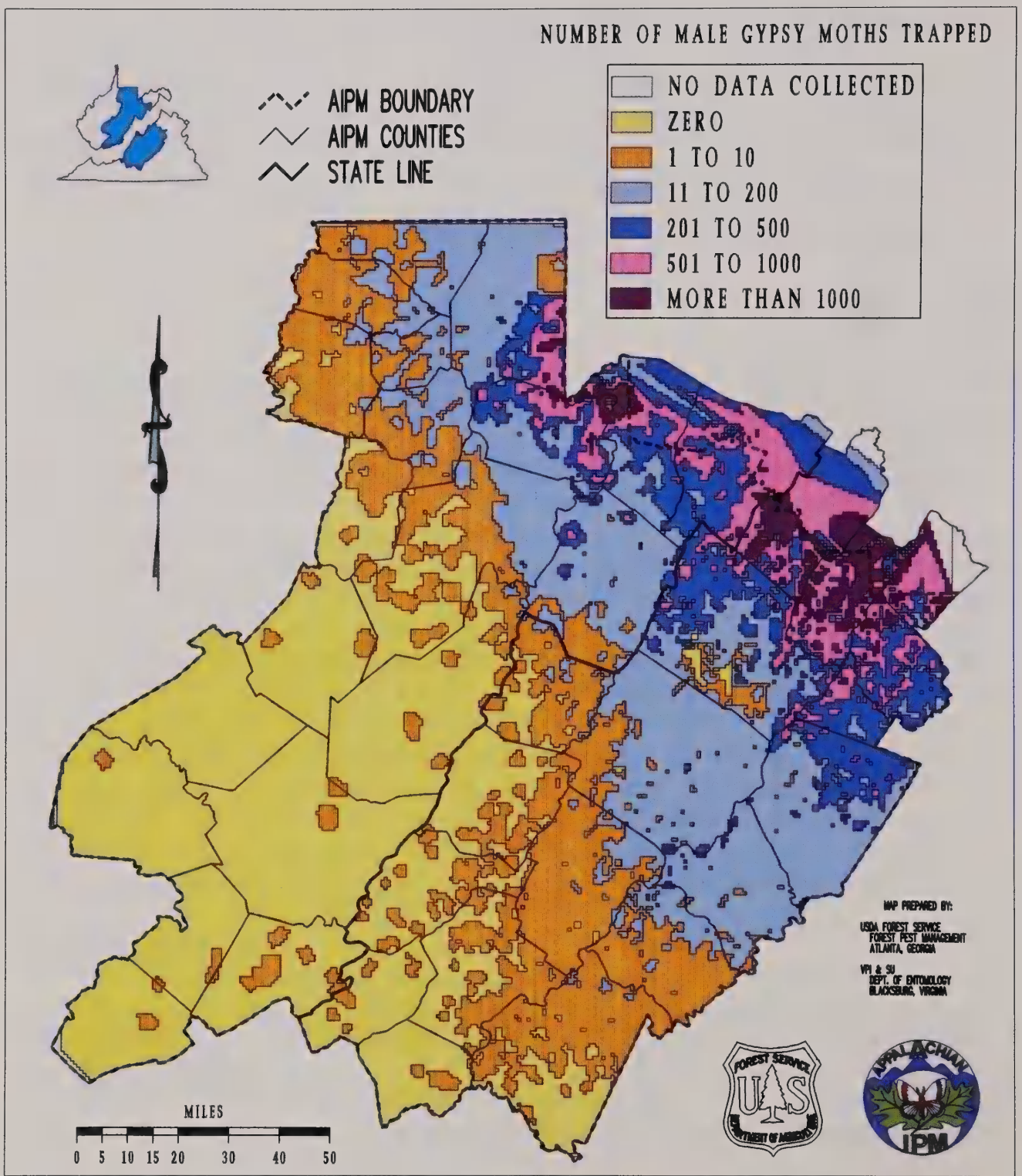

Figure 3A. *AIPM Project Area 1988 pheromone trap catch (12/88 database). Data interpolated from single site values.*

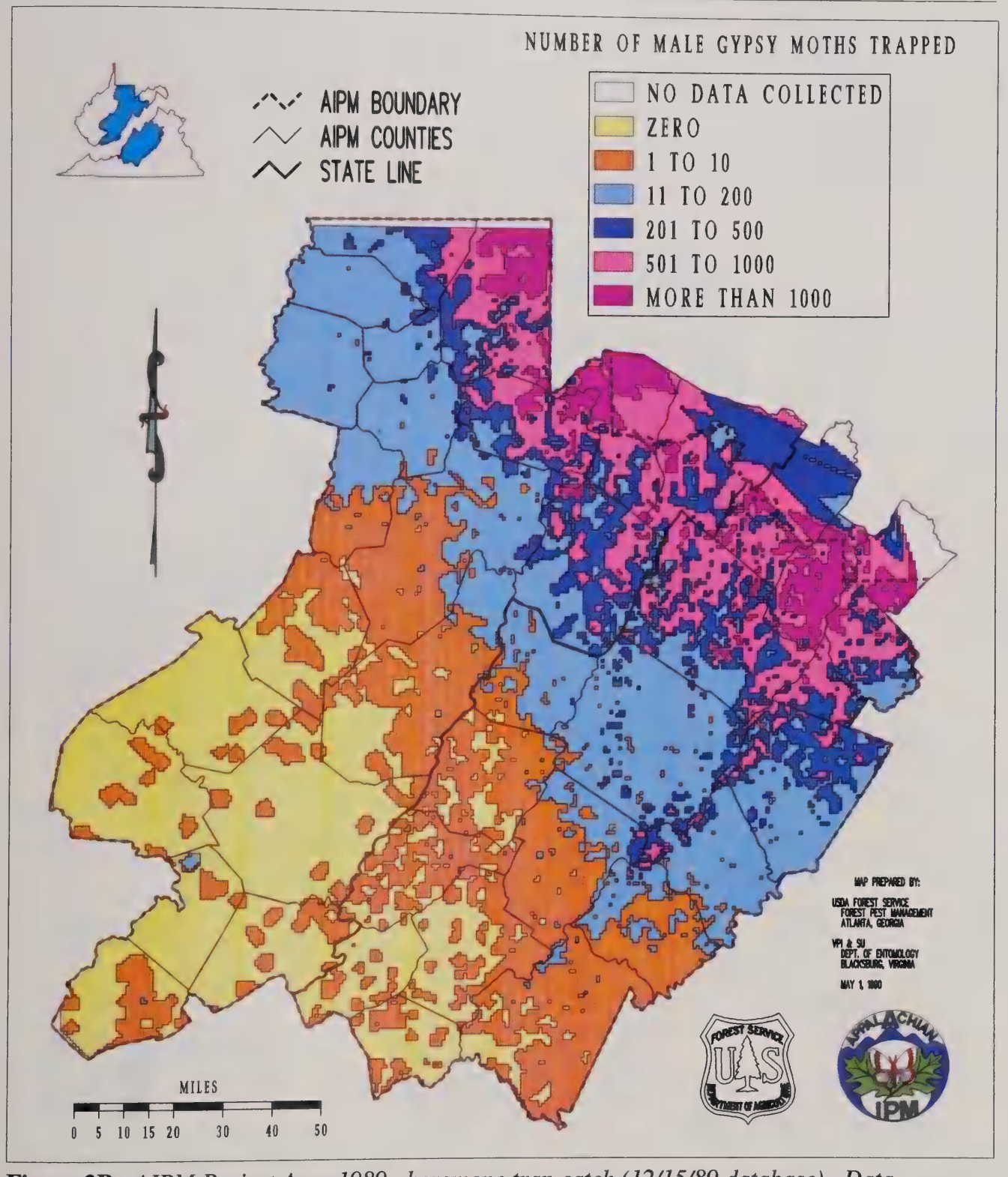

Figure 3B. *AIPM Project Area 1989 pheromone trap catch (12/15/89 database). Data interpolated from single site values.*

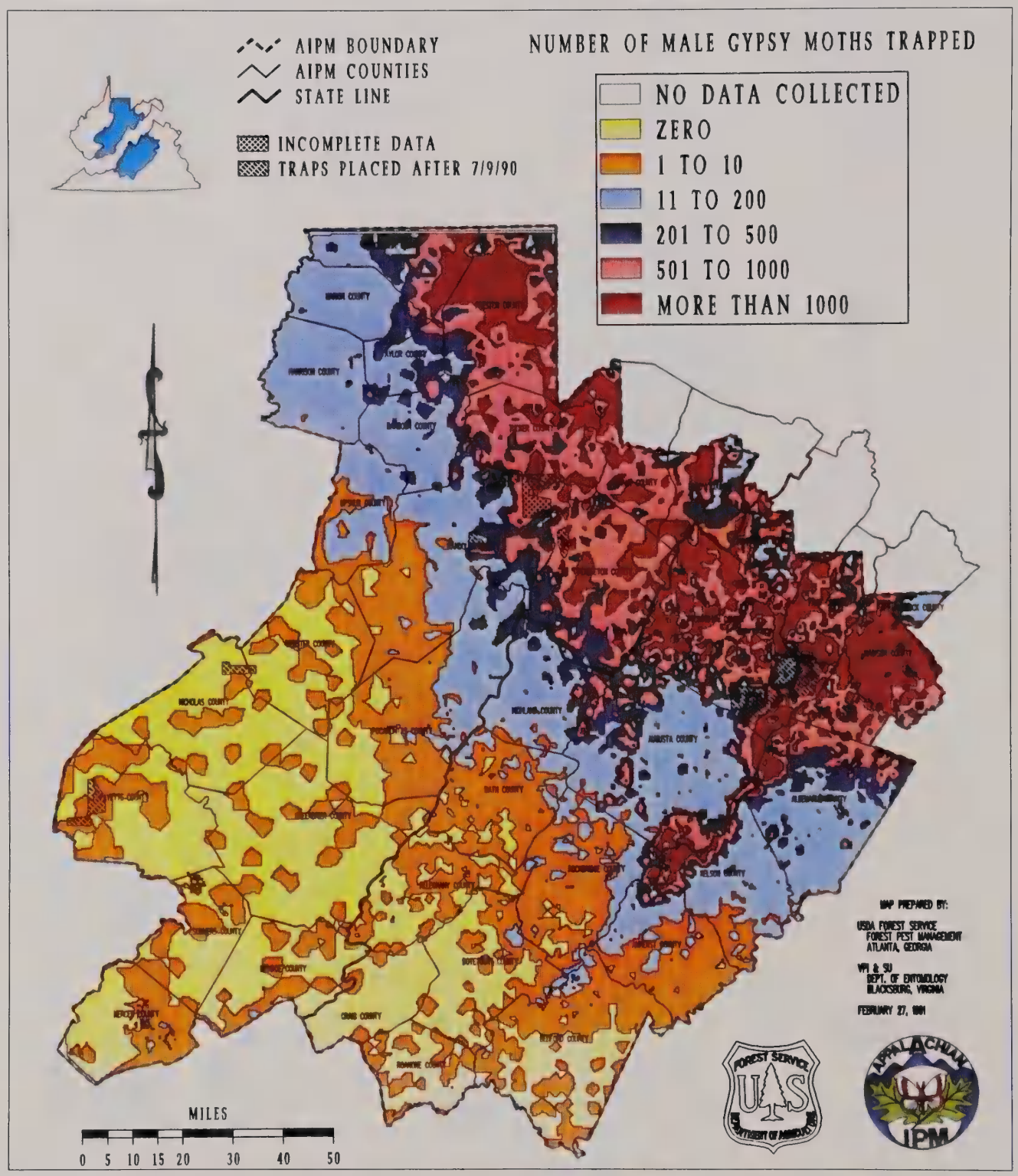

Figure 3C. *AIPM Project Area 1990 pheromone trap catch (2/8/91 database). Data interpolated from single site values.*

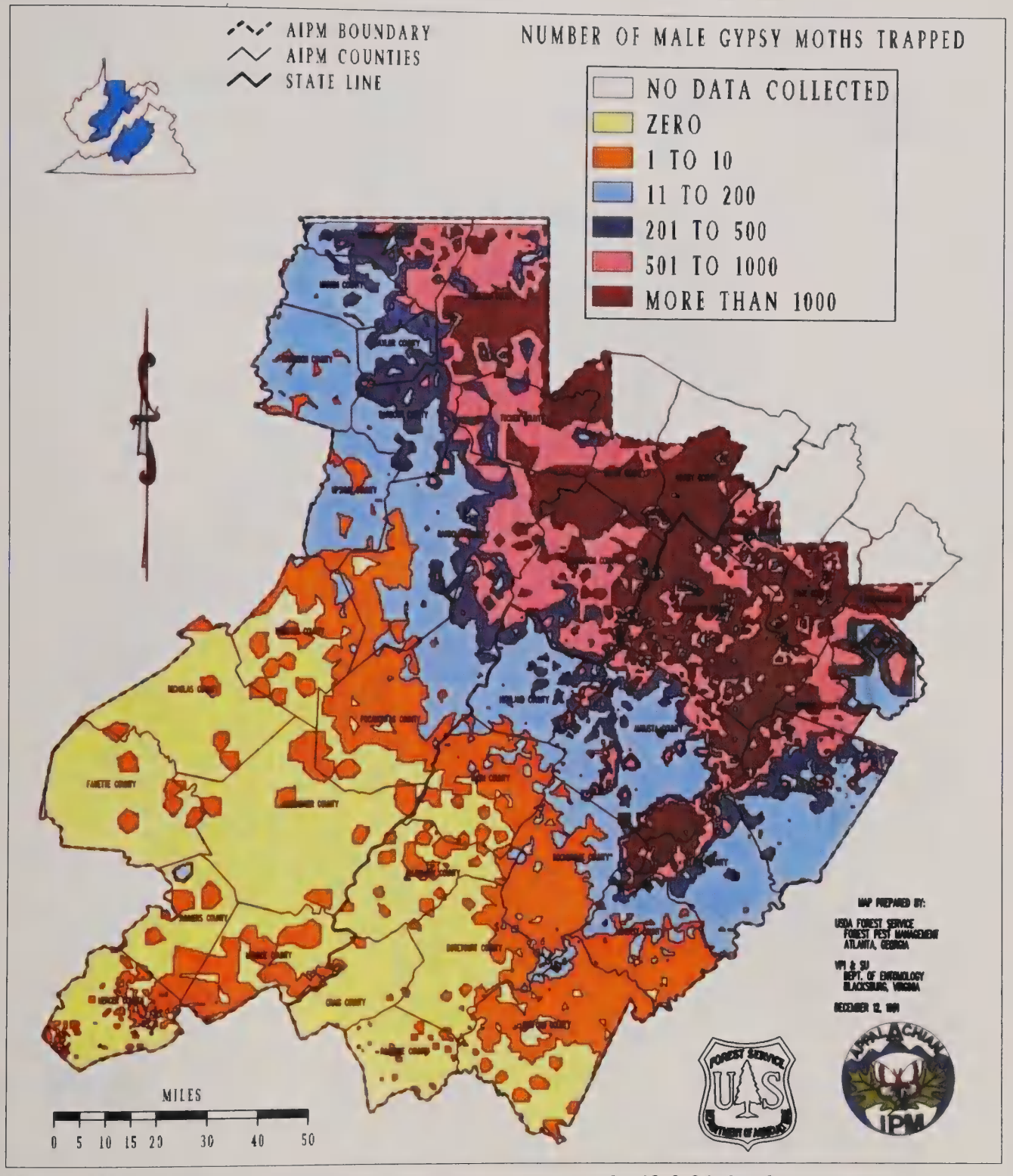

Figure 3D. *AIPM Project Area 1991 pheromone trap catch (12/9/91 database). Data interpolated from single site values.*

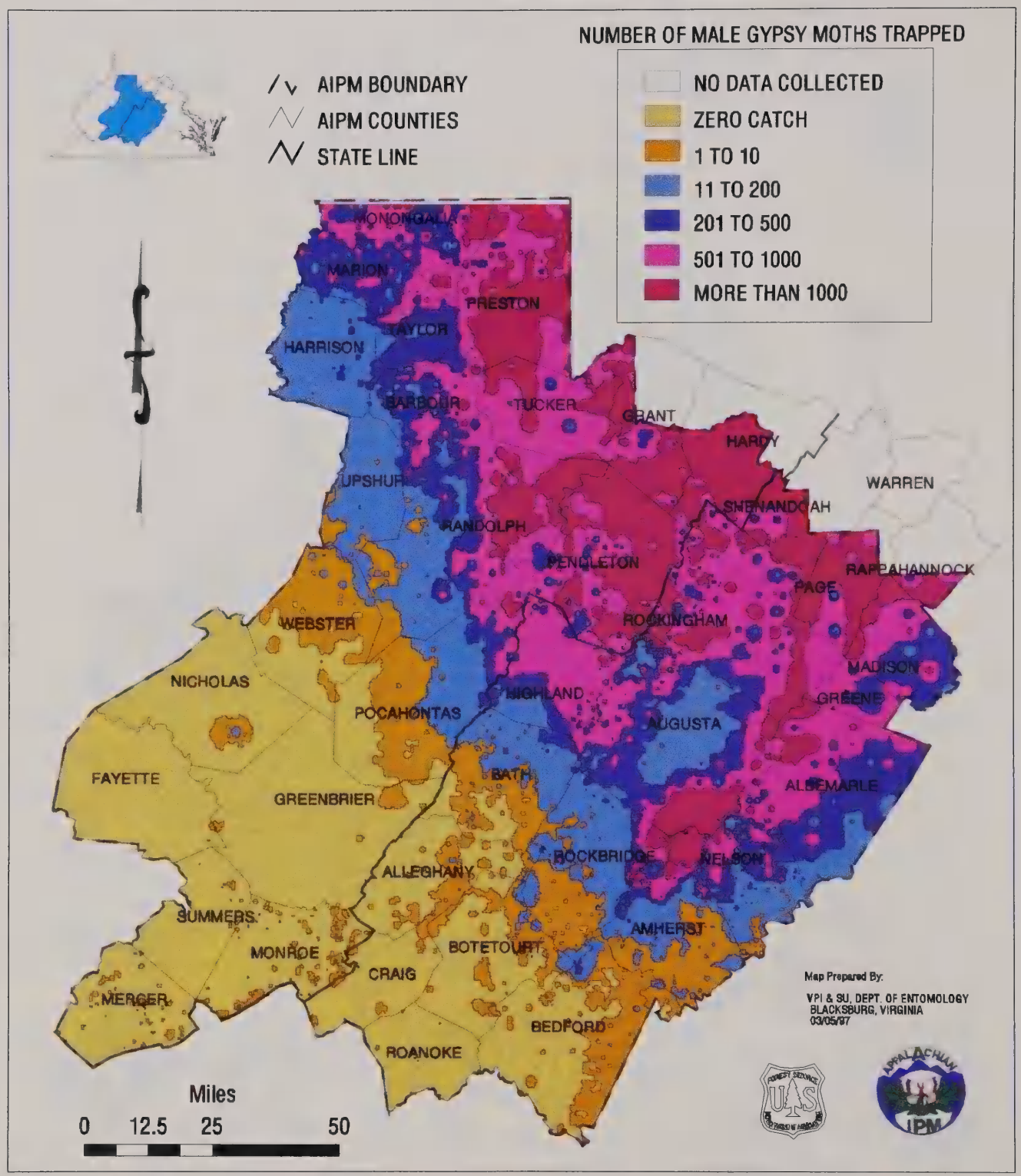

Figure 3E. *AIPM Project Area 1992 pheromone trap catch (2/10/93 database). Data interpolated from single site values.*

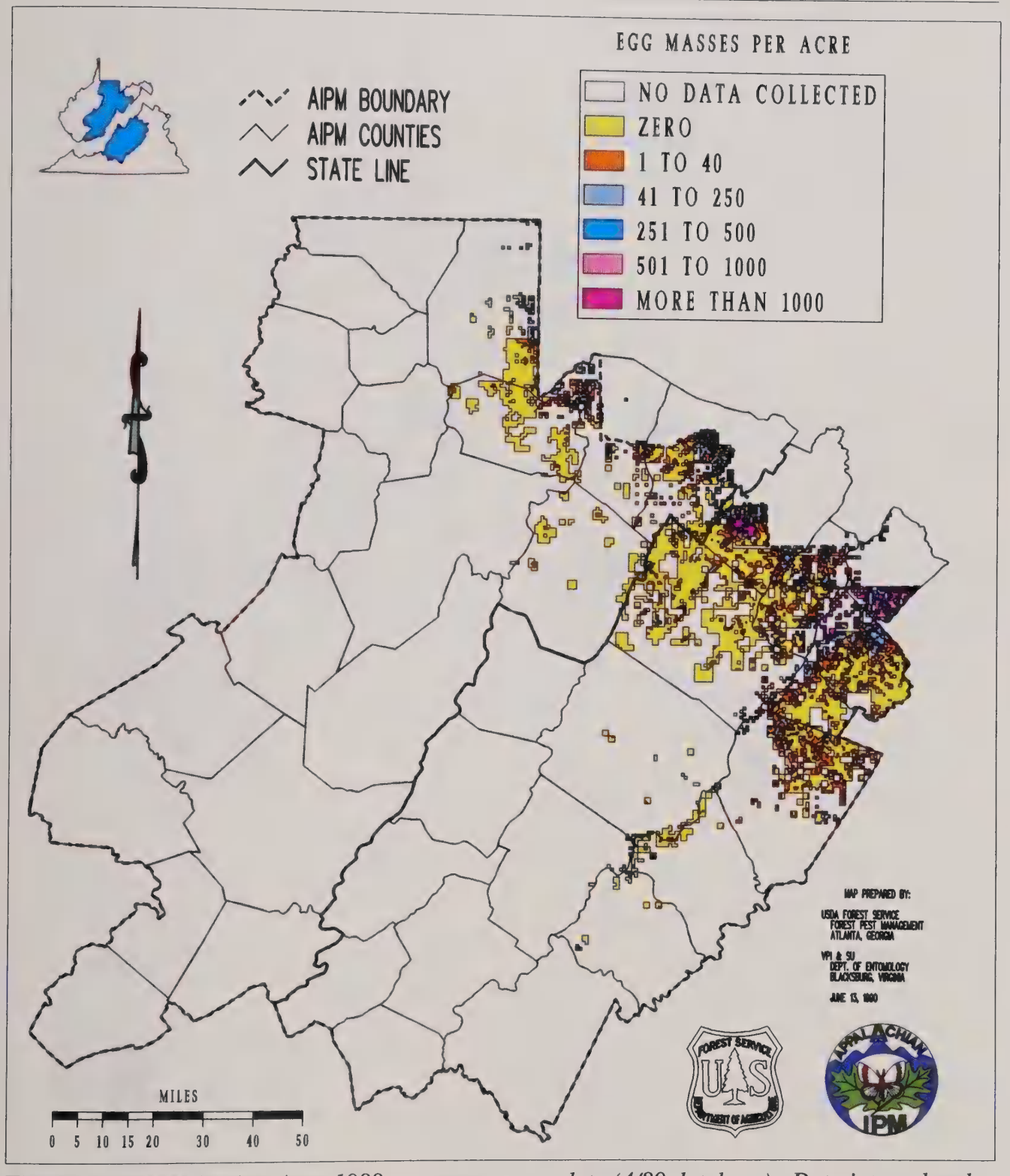

Figure 3F. *AIPM Project Area 1988 egg mass survey data (4/89 database). Data interpolated from single site values.*

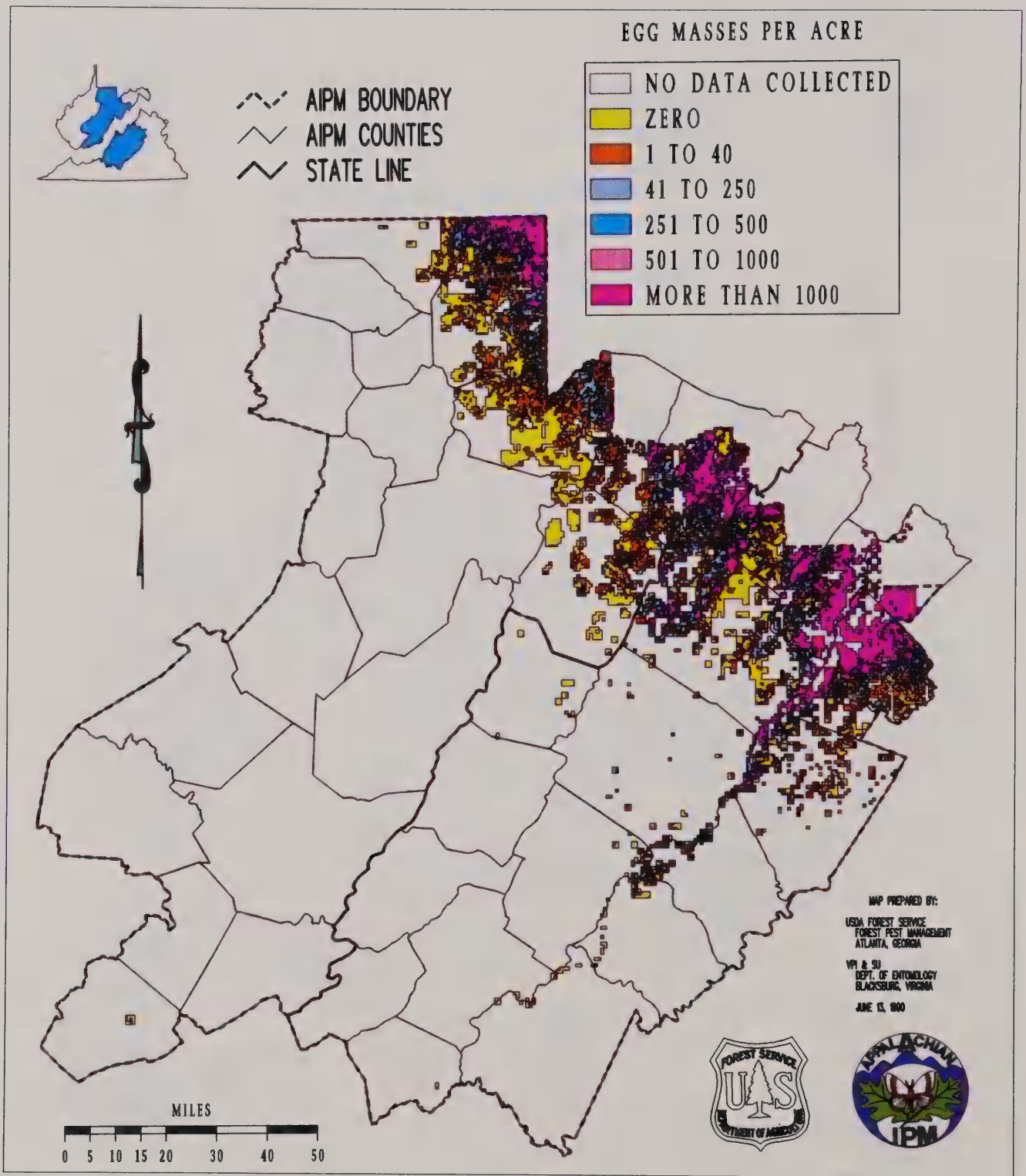

Figure 3G. *AIPM Project Area 1989 egg mass survey data (5/90 database). Data interpolated from single site values.*

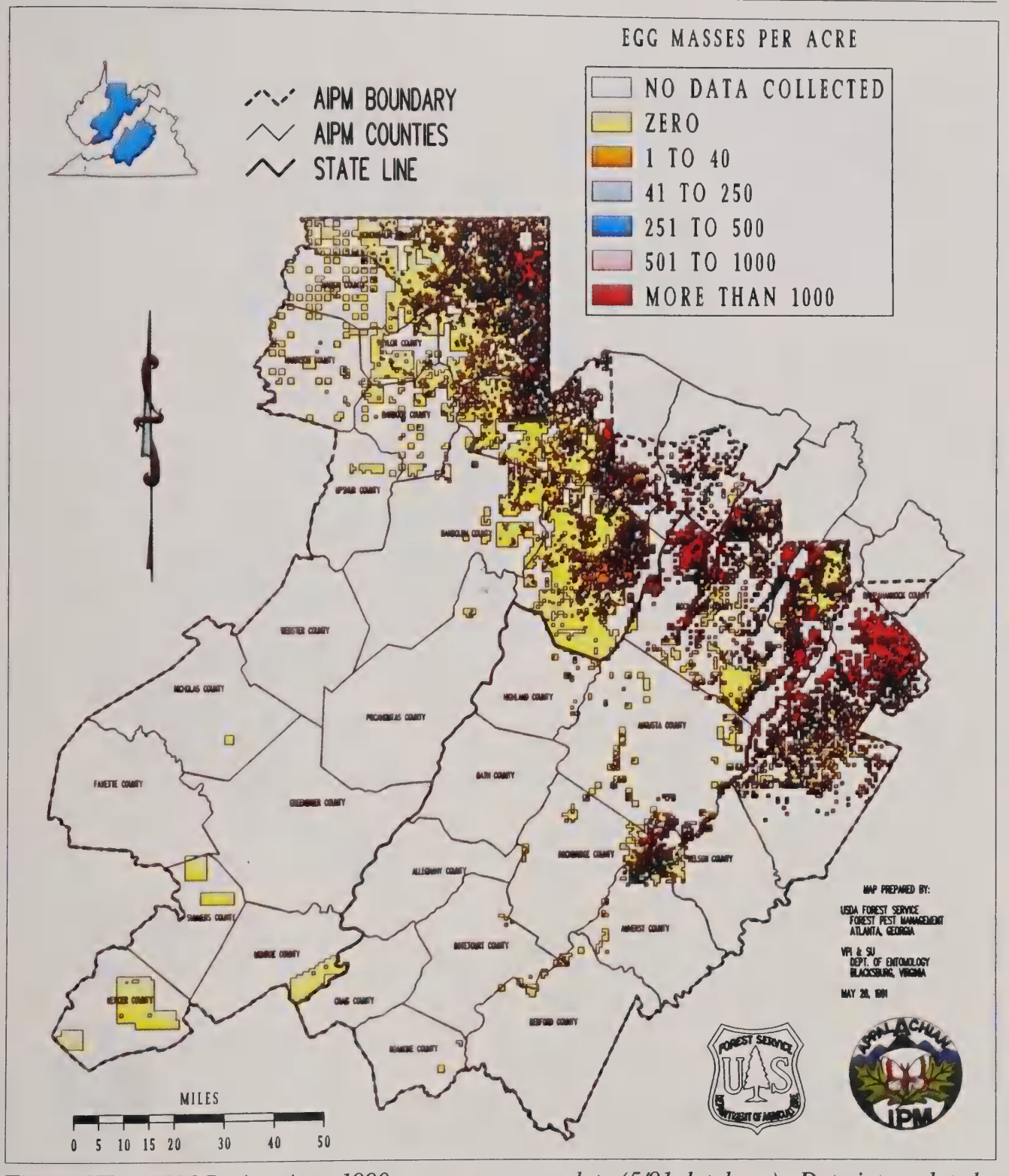

Figure 3H. *AIPM Project Area 1990 egg mass survey data (5/91 database). Data interpolated from single site values.*

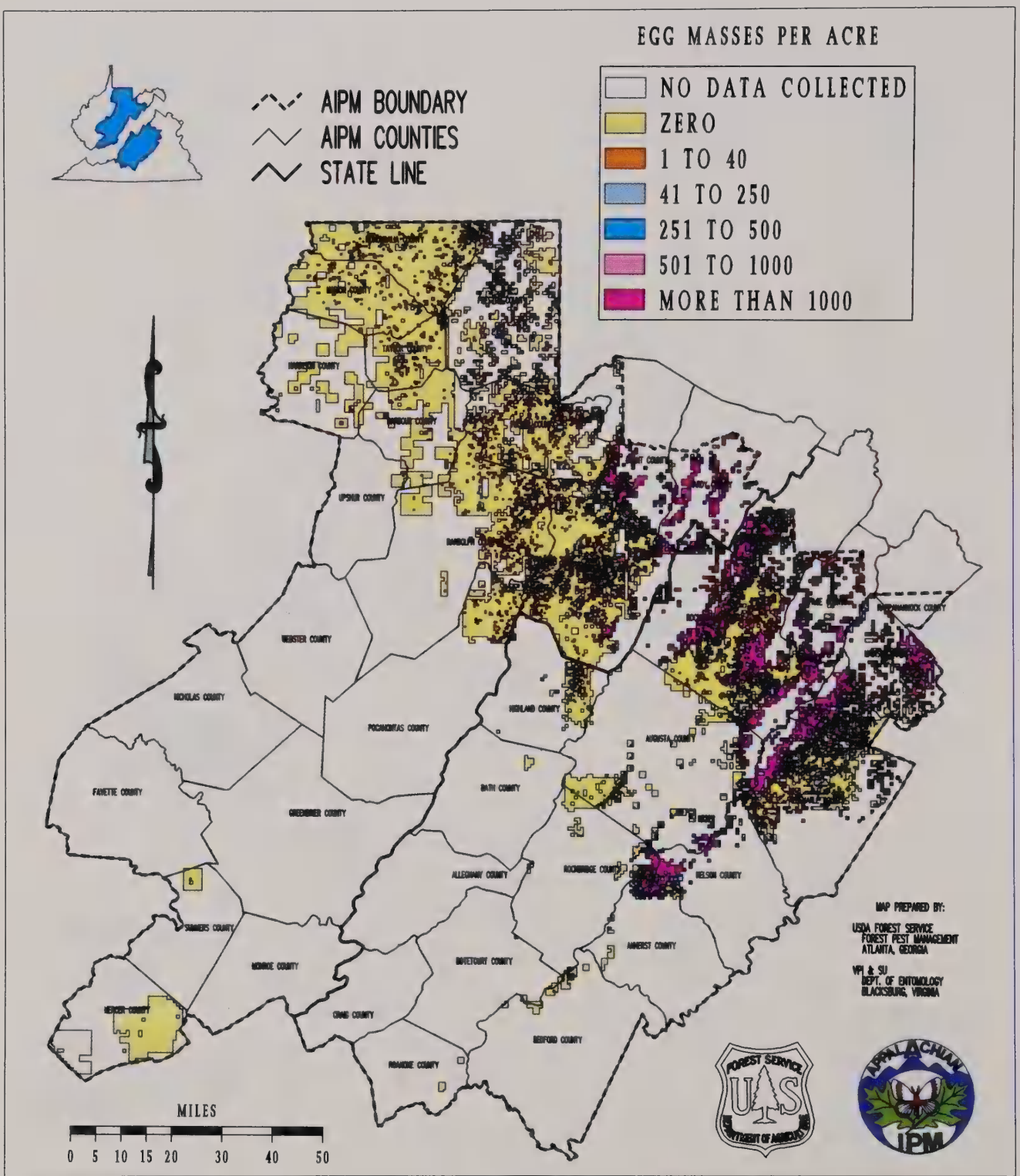

Figure 3I. *AIPM Project Area 1991-1992 egg mass survey data (5/92 database). Data interpolated from single site values.*

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